Corn Rootworm Management in Kansas Field Corn

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The U.S. EPA has expanded the Endangered Species Protection Program from four to seven counties in Kansas. These counties were originally Meade, Clark, Comanche, Stafford, and now include Reno, Rice, and Barton. While this program is still voluntary, it is expected to become mandatory in early 1995. Usage of some products may be restricted by this action.

Description and Life Cycle

Northern Corn Rootworm adults are about ¼ inch long with an overall pale green to yellow coloration. *Western Corn Rootworm* adults range from about the same size as "Northerns" to slightly larger. Their overall coloration when viewed from above is yellow with a black stripe around the margin of each wing cover. "Westerns" frequently have a dark stripe extending part way up the center of the wing covers. *Southern Corn Rootworm* adults are about ⅜ inch long and have 11 black spots on a chartreuse background. Southern corn rootworms are of little concern in Kansas in part because their eggs do not overwinter here.

Eggs of the Western and Northern species are laid in corn fields between mid-July and late September. Egg hatch begins by mid- to late May. Larvae feed on corn roots until pupation occurs in late June or early July. Mature rootworm larvae are white and slender, about ½ inch long, with brown heads and a dark plate on the top of the terminal segment. Western and Northern corn rootworms cause significant production problems in many Kansas continuous corn fields.

Damage

Corn rootworms may cause ECONOMIC DAMAGE in at least three ways. Larvae tunnel into and prune corn roots as they feed. Severe damage limits the soil nutrients the plant can take up and greatly reduces the plant's ability to tolerate drought. Reduction in the plant root system may allow the plant to lean over or 'lodge,' which then reduces the sunlight-gathering ability of the leaves and can aggravate harvesting problems. 'Goosenecked' plants at harvest, usually indicative of past lodging, are often caused by root pruning. Silk clipping by the adult beetle before pollination is complete can sometimes contribute to further yield reductions.

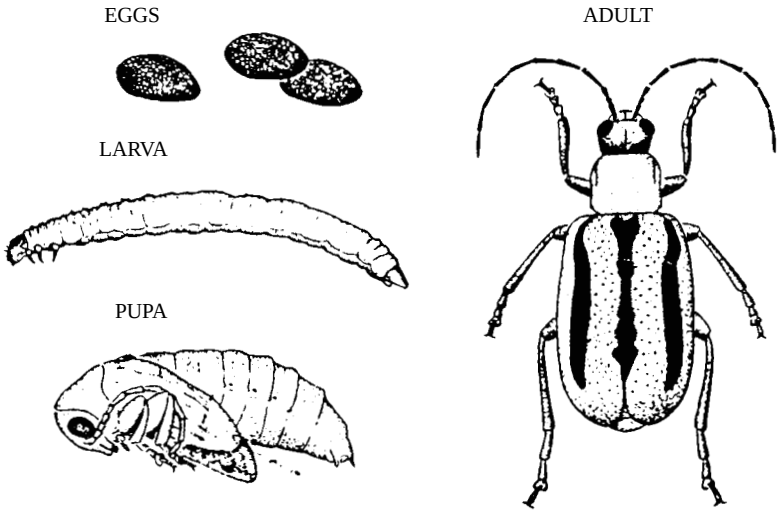


Figure 1. Life Stages of the Western Corn Rootworm. Graphics coutesy of Purdue University.

Decision-making and Insecticides

Rootworm insecticides are rarely needed if corn is planted in rotation. Volunteer corn in non-corn fields should not enhance next year's corn rootworm larval problems unless more than 4,000 corn plants per acre persist into the mid-July through September egg laying period. In some upper Midwestern states, Northern corn rootworms can survive a non-corn crop by remaining in the egg stage for two winters before hatching. To date, this phenomenon has not been confirmed in Kansas.

Rootworms are less of a problem in sandy soils and in southeast Kansas, south of U.S. 54. Late summer counts of adult rootworm beetles can be used to establish the potential for economic damage and the need for insecticide protection the next growing season (see "Beetle Counts and Future Rootworm Problems" on page 4). Although limited research has indicated that more eggs may be deposited where no-tillage is practiced, there is not a similar overall trend for increased damage as tillage declines.

Planting Time Rootworm Insecticides

On continuous corn land where rootworm problems are expected to occur, use one of the products recommended in MF-810, *Insect Management for Corn.* If one product has been used for two or more consecutive years, it is advisable to select a different product for the current season, because enhanced microbial degradation could break down compounds rapidly. In general, this phenomenon is more likely to occur with some carbamate insecticides than with organophosphates.

Generally, granular materials are recommended for most consistent larval rootworm control in Kansas. Placement of insecticide is very important and varies depending on the product. Granules should usually be placed in a 6- to 8-inch band over a closed seed furrow (chlorpyrifos is an exception—see below). Mechanical devices may be necessary to guarantee seed slot closure before certain insecticides are placed on the ground. Note that the chlorpyrifos (Lorsban 15G) label states that a T-band placement may improve product performance in some situations. (The insecticide is dropped in a band, part of which is allowed to fall into the seed furrow before the slot is closed.)

See MF-1068, *Corn Rootworm Management for Early-Planted Corn*, for more information on this topic, particularly where planting before April 20 is under consideration.

Equipment Modification and Maintenance

Otherwise cost-conscious farmers frequently overlook proper equipment maintenance. Remember that when changing products, you must recalibrate your applicators. Two 15G products (15 percent active ingredient, 85 percent inactive carrier, such as clay or corn cob grits) may look alike but often have very different flow rates.

A potentially more serious oversight is changing from one concentration of active ingredient to another. Equipment should be recalibrated at least yearly. (A recent survey of farmer-operated equipment noted that 13 percent were applying less than 80 percent of the recommended rate, 10 percent were applying more than 20 percent too much, and over half the planters had individual application units that varied from the ideal rate by more than 20 percent.)

Wind guards can help keep granular products from blowing away from the row. Be sure band spreaders are not too high off the ground and confirm that in-furrow delivery tubes are not excessively long or curved to restrict free flow of granules.

Ribbed press wheels, drag chains, and/or spring tines should be used to lightly incorporate the granules in the top 1 inch of the soil. With some products, if the insecticide is placed deeper, as would be the case when granules are being applied in front of the covering disc or with the seed, inadequate protection or direct seed injury may result. Furrow closers may be required under certain soil conditions to prevent insecticides from contacting the crop seed directly.

Even if the label allows "in-furrow placement," experience in Kansas indicates that better root protection usually results when the product is **banded** over a wider portion of the root growing area. However, in-furrow treatment may provide better protection from wireworms or other seed corn pests and still give adequate corn rootworm control in many instances. Placing the insecticide below the seed level (as may occur if mixed and applied with some fertilizers) is **not** effective.

Most products will work reasonably well if applied carefully and if extremes in environmental conditions do not continue. *Lorsban* is one of the most insoluble products, whereas *Furadan* and *Mocap* are the most soluble. Very dry or very wet conditions after planting could cause inadequate or excessive product movement or leaching in some soil types.

Other situations that put more pressure on the products (meaning that, in some instances, control may be less than acceptable) include:

- Excessively late planting the year before (attracting a much larger number of egg-laying beetles)
- Inadequate calibration or poor application techniques
- A very mild winter which may aid egg survival
- Very early planting (before April 18) which may allow planting time treatments to degrade or leach out of the area before the rootworm eggs hatch
- Applying cultivation treatments too late to give protection
- "Conditioned soils"—microbial populations that degrade the product have increased residue levels remaining from planting-time treatments are inadequate to protect roots when larvae emerge from eggs several weeks after planting
- Although much less likely, rootworm resistance to a product may have increased.

Cultivation Time Treatments

Basal application has been approved for most of the listed larval rootworm insecticides. Over-the-row applications are labeled for *carbofuran*, *chlorpyrifos*, *ethoprop*, and *terbufos*. Insecticides should be applied before rootworm damage has become severe (mid-May through mid-June), preferably before the larvae reach the most damaging, third-larval stage.

Most labels specify application in combination with cultivation to enhance product activity. Adequate precipitation or soil moisture must be available to move the products throughout the rootworm feeding zone. Cultivation also may promote some additional root development from lower stalk nodes placed in contact with the soil. This additional root development can be important in helping the plant recover from severe rootworm injury. The number of larvae needed to warrant cultivation

PLACEMENT OF ROOTWORM INSECTICIDES

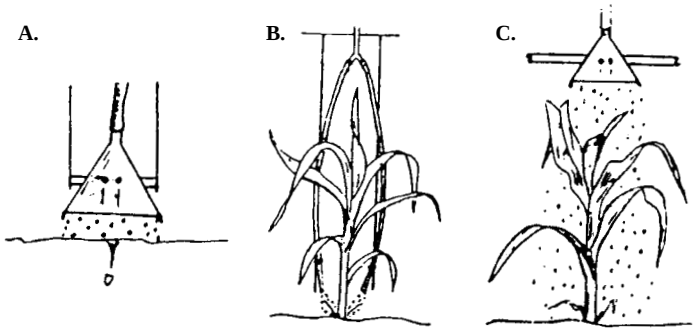


Figure 2. Application of rootworm insecticides:
A. banded at planting time.
B. basal application of cultivation treatment.
C. over row application of cultivation treatment.

treatments (if planting time treatments have not been used) varies from three to ten larvae/plant and probably depends greatly on the care a person uses in locating the tiny larvae.

Several studies have shown that if adequate moisture is available, post-planting cultivation-time treatments provide equivalent or sometimes superior root protection when compared with planting-time treatments. However, there are several reasons cultivation-time treatments are not commonly used. These include: (1) very dry soils which limit movement of the product into the root zone; (2) concern that timely cultivation and insecticide application may not be possible; (3) lack of access to toolbar-mounted granular applicators.

Delayed Post-Planting Broadcast Applications

Broadcast applications of carbofuran (Furadan 4F) made by airplane are receiving more attention from some producers. Timing and post-application moisture (rainfall or irrigation) are critical for success.

Evaluation of Efficacy

Simple yield comparisons seldom have enough resolution for a user to compare product performances. Leaving an untreated control or 'check' area of two to four rows wide and 20- to 40-feet long at three or more locations in the field permits the user to accomplish two important objectives. First, the need for any rootworm insecticide can be assessed 'after the fact' by looking at roots removed from the untreated areas. Second, the performance of the product can be evaluated by assessing damage to roots from the treated areas.

Be sure to "flag" or otherwise mark the untreated areas at planting for relocation during the vegetative phase when damage evaluation must occur. Evaluation (by digging and washing root masses) must occur after damage peaks but before root regeneration masks the injury. This means roots usually must be rated in early July.

'Root rating' is the method used to assess product performance indirectly. To evaluate the extent of damage, representative plants must be destroyed and the roots dug. Select five or more plants from each area and cut off the stalk about 12 inches above ground level. This will give you a convenient "handle" with which you can move the root ball around. Take as much root tissue as possible (a 7-inch × 7-inch × 7-inch cube). Keep treated and untreated plants separated.

Soak the root ball in a large container of water (washtub, garbage can, etc.) until the soil softens enough that a high pressure water stream easily washes the roots clean. Then, immediately assign each plant a root rating from 1 (no visible damage) to 6 (severe damage) as indicated in Figure 3. Be wary of confusing causes of injury such as "cultivating too close to the row) and, in certain southwest Kansas areas, nematode injury.

The fewer roots intact, the more stress the plant is likely to undergo. Failure to keep the average root rating below 2.75 to 3.00 could mean that the insecticide did not perform as expected. A "2" means that the only visible damage is restricted to 'feeding scars'. A "3" indicates that at least one root has been chewed back to within 1½ inches of the plant. Several other roots also may be pruned, but less than one entire node of roots must be severely pruned for a rating of "3" to be assigned. (Refer to the drawing for the six rootworm injury categories.)

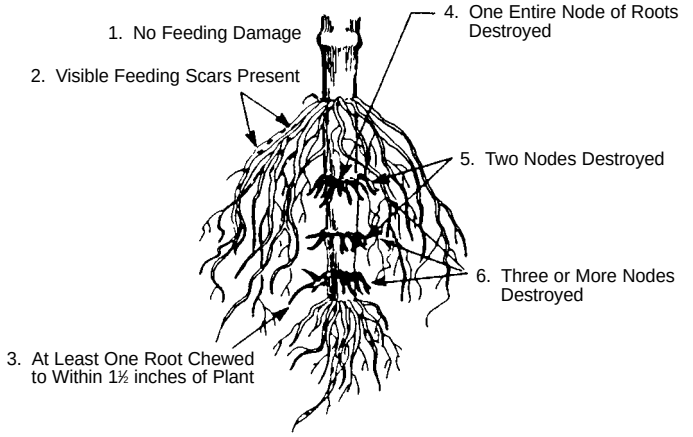
Corn Rootworm Adult—Silk Clipping Protection

Damage is caused when adult beetles disrupt pollination by early silk clipping. Silk clipping AFTER pollination does not affect yield. Foliar spray treatments are probably justified if there are eight to ten beetles per plant and 10 percent of the silks are just beginning to show (production corn). In corn fields stressed by other factors or where hybrid seed corn is being produced, as few as five beetles/plant may cause economic yield losses. Obviously, even fewer beetles may cause problems where low-vigor inbreds are being grown.

Beetle Counts and Future Corn Rootworm Problems

In continuous corn fields, counts of fall egg-laying Western and Northern beetles can be used to determine whether soil insecticides will be necessary the following spring. Fields must be scouted at least weekly from

Figure 3. Description of the Iowa State University 1 to 6 root damage scale. (From Nebraska Nebguide G82-597)



Rating	*Description of root system*
1	No noticeable feeding damage.
2	Feeding scars present but no root pruning.
3	At least one root pruned but less than an entire node of roots pruned.
4	At least one full node of roots pruned but less than two full nodes.
5	At least two full nodes pruned but less than three full nodes.
6	Three or more full nodes of roots pruned.

To qualify as a pruned root, the root must have been pruned to within 1½ inches of the plant. It is not necessary that the number of roots pruned is equivalent to that in a full node.

July 1 through August and sometimes into September.

Grasp the ear tip of the sampled plant with the palm to prevent beetles escaping while the plant is examined. Pay close attention for beetles hiding where the leaf joins the stalk. When the silks are released, count the beetles as they leave. Either of the following methods can be used to evaluate the seriousness of late summer and fall egg-laying.

Sequential Sampling Method

This method minimizes your time in the field when populations are "high" or "low" and helps ensure that "border line" populations are given proper consideration when making a treatment decision.

Step 1: Total beetle counts from groups of two non-adjacent plants per location are compared against the Sequential Sampling Decision Table.

Step 2: Sampling is discontinued for the year if a "High" population is noted. **Decision:** rotate out of corn or use a soil insecticide for rootworms next spring.

Step 3: "Low" populations mean sampling is postponed for seven days, then the process is repeated. If population counts are low throughout the season, no planting-time rootworm insecticide will be needed next spring.

Step 4: Sampling continues as long as the "Undecided" population category exists. A maximum of 54 plants are examined on any one date, then resampled in five days if neither the "Low" nor "High" category was reached.

Table 1. Determining the need for a soil insecticide through sequential sampling surveys of adult rootworms the previous year.

	Total Beetle Count		
Number Plants Sampled	Resample in 7 Days	Continue Sampling	Rotate or Use Soil Insecticides
10	0–2	3–17	18+
12	3–4	5–19	20+
14	5–6	7–21	22+
16	7–8	9–23	24+
18	9–10	11–25	26+
20	11–12	13–27	28+
24	13–16	17–31	32+
28	17–20	21–35	36+
32	21–24	25–39	40+
36	25–28	29–43	44+
40	29–32	33–48	49+
44	33–36	37–52	53+
48	37–40	41–56	57+
52	41–44	45–60	61+
54	45–46	47–62	63+
Population Category	Low	Undecided	High

Alternative Sampling Method

Step 1: Count beetles from five or more areas of the field on at least 100, non-adjacent plants.

Step 2: If counts exceed an average of one beetle/plant, respond as in Step 2, "Sequential Method".

Step 3: If the average beetle count per plant is below 0.25, respond as in Step 3, "Sequential Method."

Step 4: Average weekly counts between 0.25 and 1.00 beetle per plant indicate 'Undecided' and sampling must be repeated at regular intervals.

Adult Control as an Alternative to Soil Insecticides

Adult control can be employed to suppress egg-laying below levels that can result in economic damage by the larvae next summer. This method is only recommended for those willing to rescout the field on a regular basis.

Scout the fields weekly from first beetle emergence through termination of egg laying. Either whole plant or ear zone counts can be used. The ear zone includes that part of the corn plant bracketed by the lower surface of the leaf above the ear, down to and including the upper surface of the ear leaf below the ear.

If beetle counts reach or exceed 1.0 (using the whole plant count) or 0.6 (using the ear zone count) beetle per plant and 10 percent of the females are swollen with eggs (gravid), a spray application of *Sevin-4-oil* or *Penncap-M* must be made immediately. Female western corn rootworms have two black stripes on their wing covers, and the sex organs curl outward when the beetles are squeezed.

If beetle numbers return to an average of 0.3 per ear zone after spraying, immediate retreatment is necessary. Two sprays will often be more expensive than a single, planting-time application of a soil insecticide. Late developing fields are not good choices because large numbers of gravid females may migrate into these fields. Do not treat fields which have had more than one or more beetles per plant with 10 percent of the females gravid for more than seven days.

Research is being conducted on products composed of mixtures of insecticides (usually tiny concentrations of insecticides are needed (0.02 to 0.035 lb. A.I./A is being used) if the stimulant/arrestant effectively keeps any rootworm adults encountering and feeding on the mixture interested long enough for a lethal dose of insecticide to be ingested. Compel and Slam are examples of these products which are being evaluated in Kansas. The concept is promising but more evidence that the products are rainfast is needed before broader confidence in the concept develops.

Growers contemplating adult corn rootworm control in fields with developing mite problems should read the mite section of MF-810, *Corn Insect Management*, and publication MF-762, *Managing Spider Mites on Field Corn and Grain Sorghum*, before spraying with carbaryl.

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MF-845 (Revised) May 1995

File Code: Entomology—2